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EP 0145966 A2 EP 0115575 A2 US 5347293 A
US 4760389 A

(58) Field of Search
UK CL (Edition N) G1A AMS APF , G5C CHB CHX
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ONLINE:EDOC WPI JAPIO

(54) **Controlling display brightness**

(57) To control the brightness of a display the environmental light intensity is detected and a variation time function of the light intensity calculated. This function is then used to predict a time function of the degree to which the pupil of a human eye is open. The optimal value for the brightness of the display is then determined on the basis of the predicted time function. This system is useful for adjusting the brightness of a display in a vehicle following abrupt changes in the ambient light level.

FIG. 2

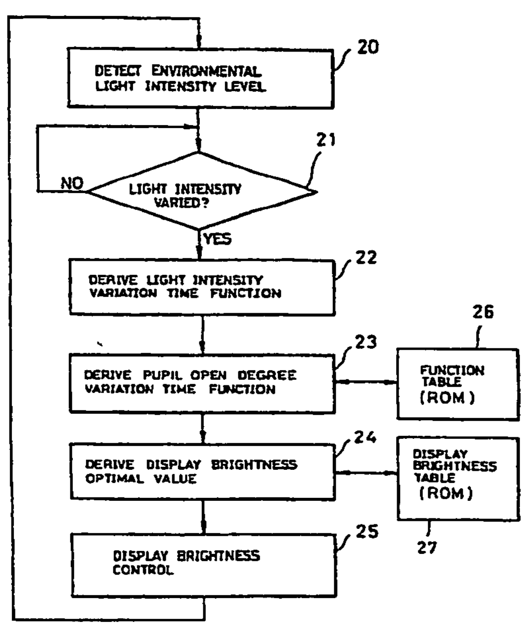

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FIG.1

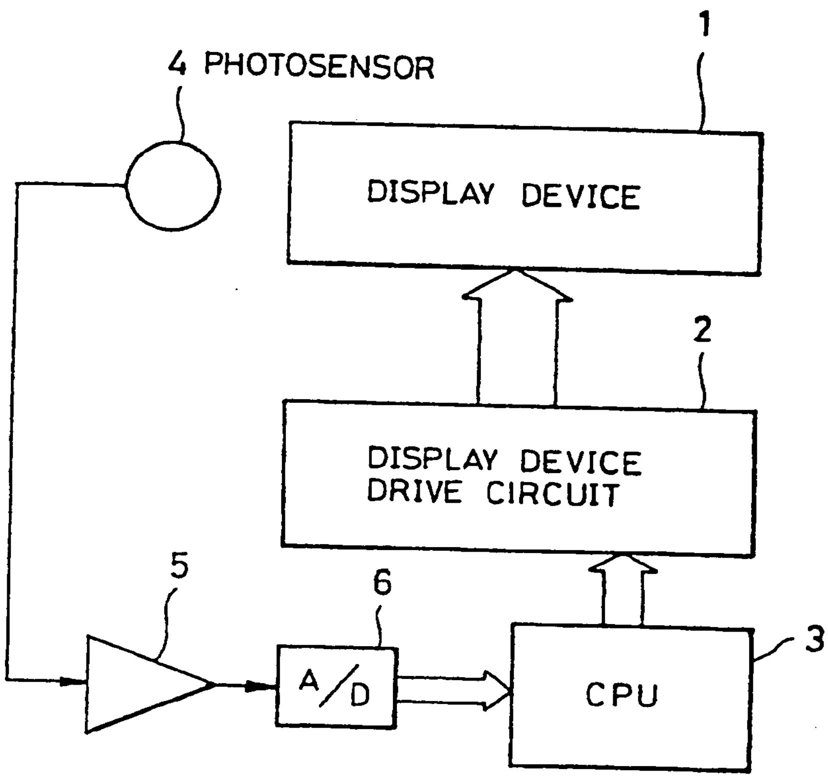
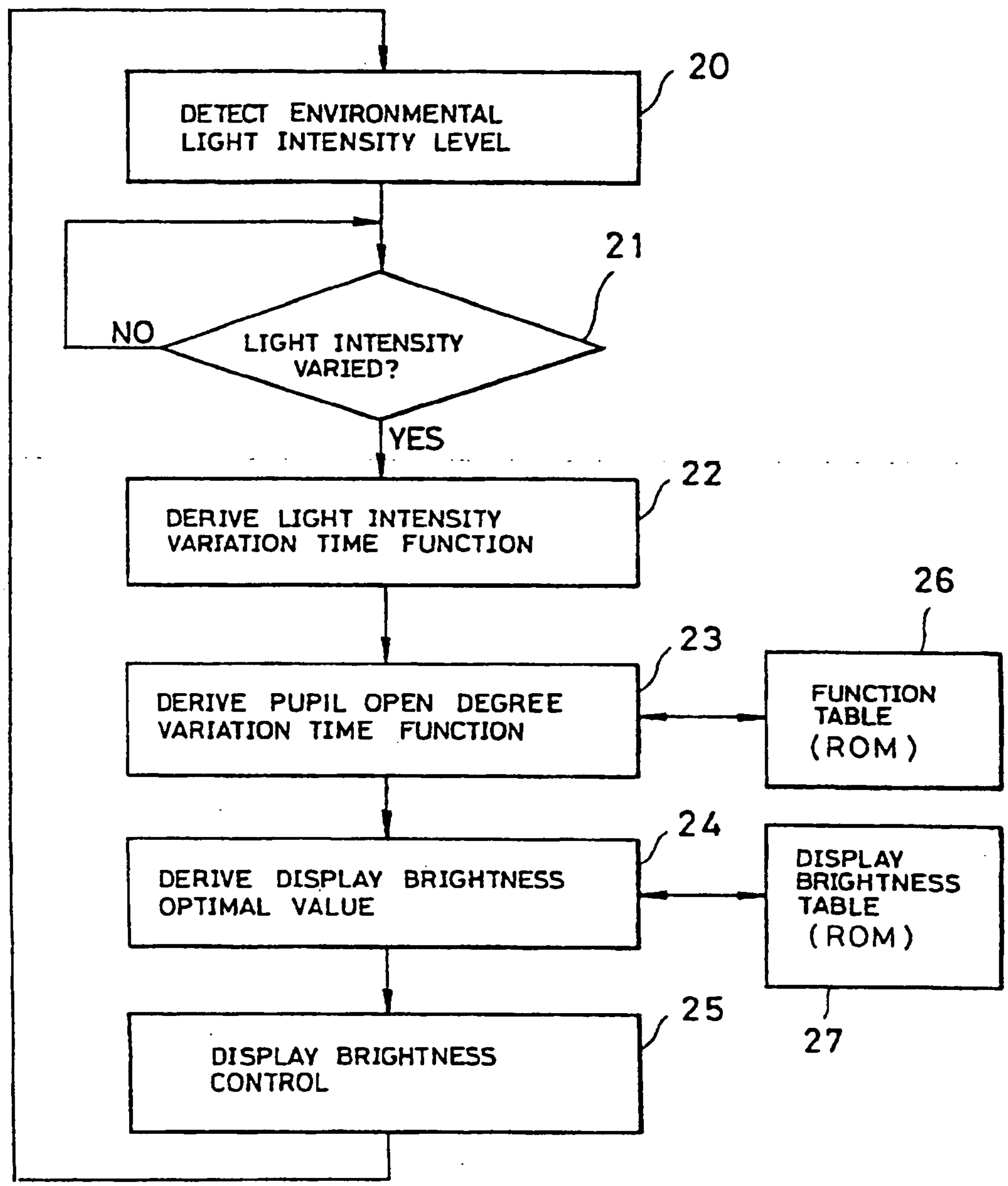

4 PHOTOSENSOR
1
DISPLAY DEVICE
2
DISPLAY DEVICE
DRIVE CIRCUIT
5
6
A/D
CPU
3

FIG. 2



20
DETECT ENVIRONMENTAL LIGHT INTENSITY LEVEL
21
NO
LIGHT INTENSITY VARIED?
YES
22
DERIVE LIGHT INTENSITY VARIATION TIME FUNCTION
26
23
DERIVE PUPIL OPEN DEGREE VARIATION TIME FUNCTION
FUNCTION TABLE (ROM)
24
DERIVE DISPLAY BRIGHTNESS OPTIMAL VALUE
DISPLAY BRIGHTNESS TABLE (ROM)
25
27
DISPLAY BRIGHTNESS CONTROL

FIG.3

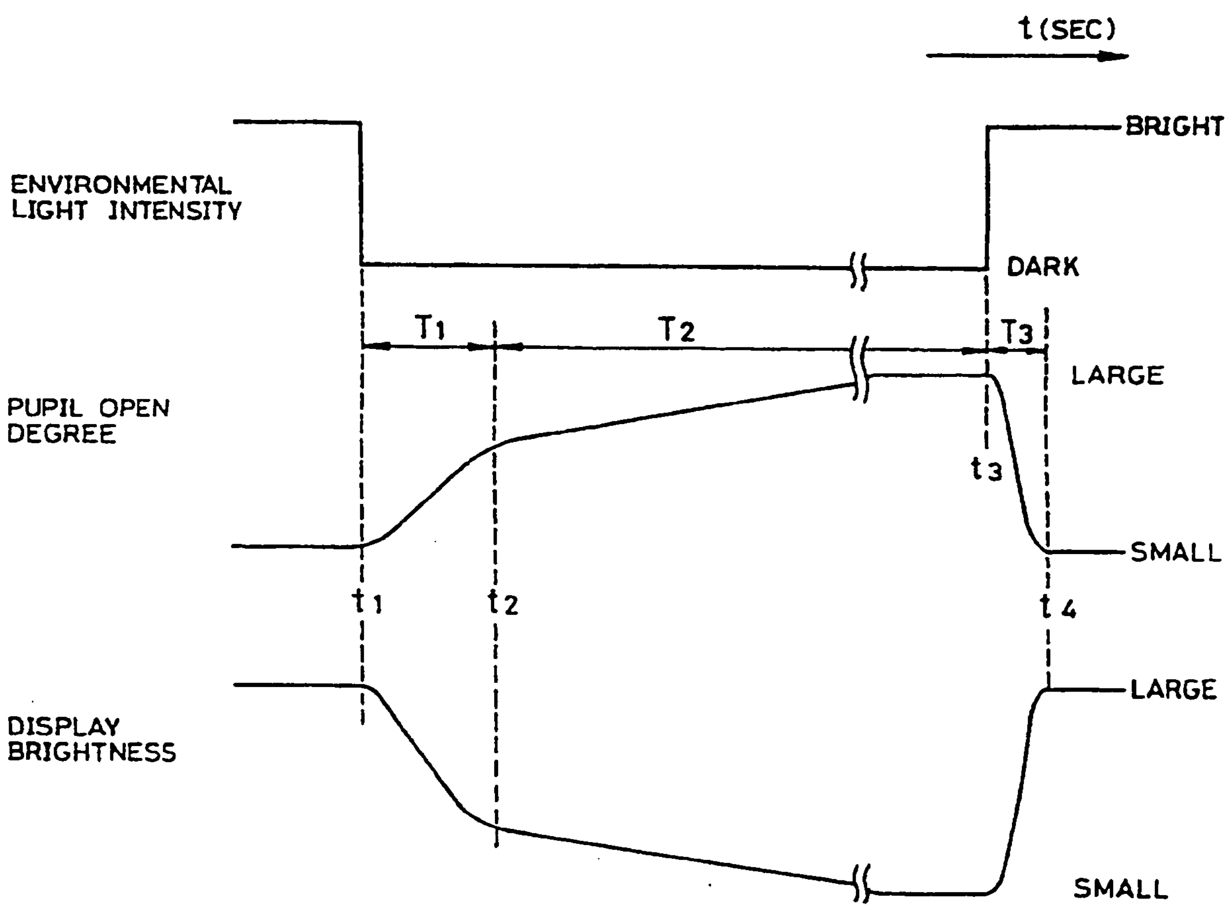

t (SEC)
ENVIRONMENTAL LIGHT INTENSITY
BRIGHT
DARK
T1
T2
T3
PUPIL OPEN DEGREE
LARGE
SMALL
t3
t1
t2
t4
DISPLAY BRIGHTNESS
LARGE
SMALL

FIG. 4

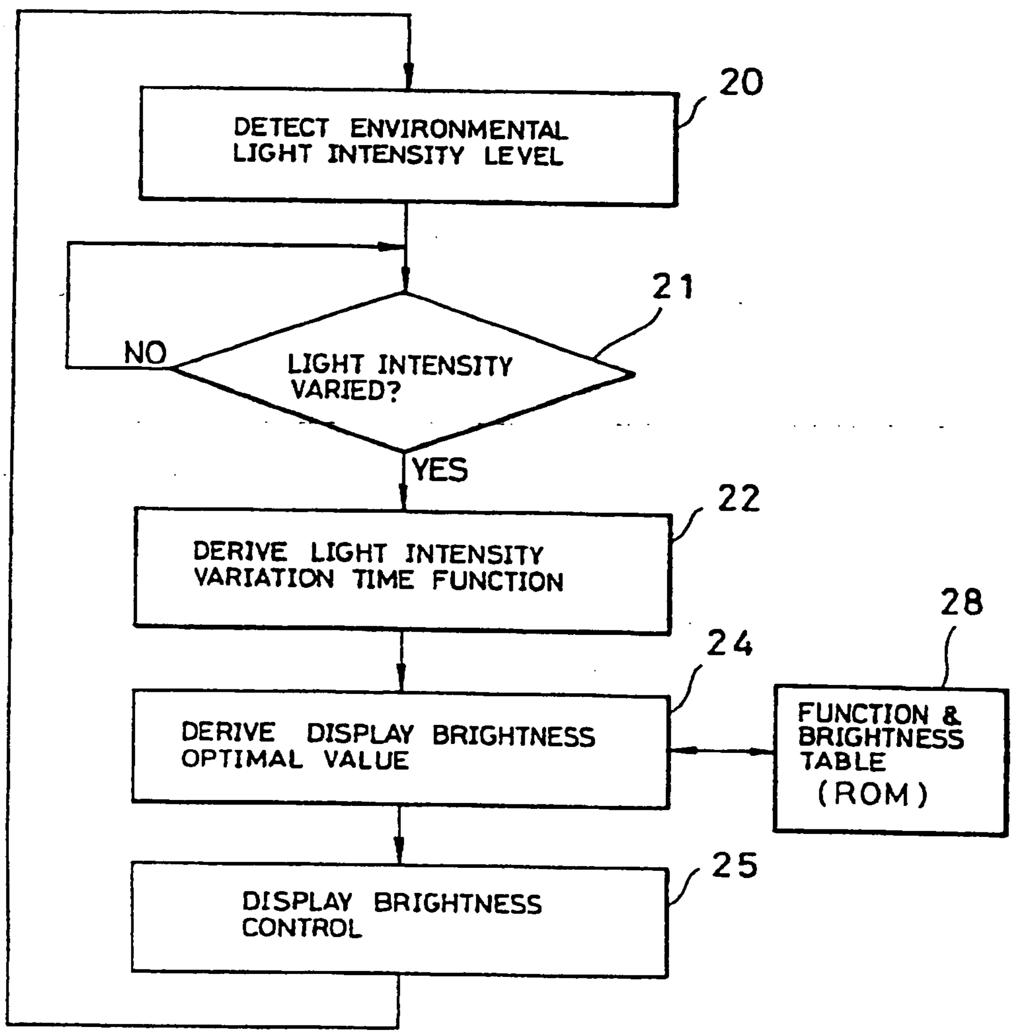
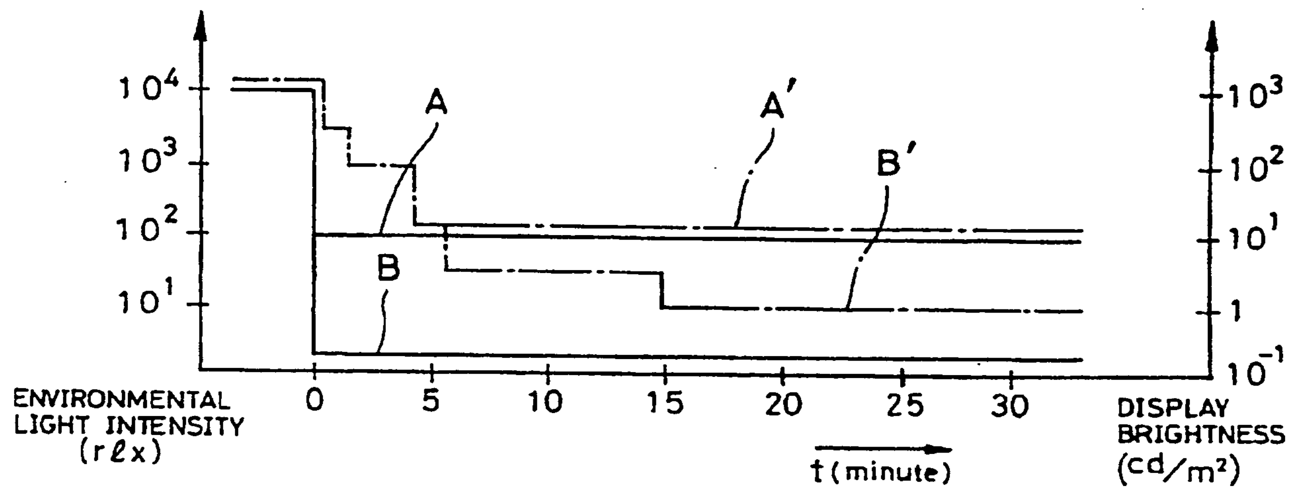
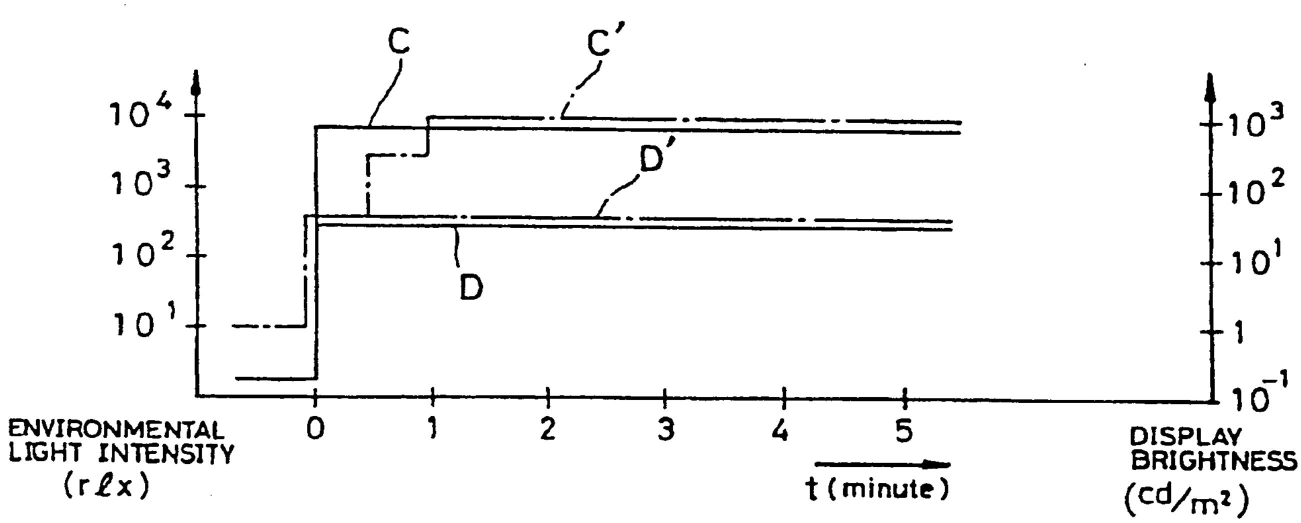

DETECT ENVIRONMENTAL LIGHT INTENSITY LEVEL
20
LIGHT INTENSITY VARIED?
21
NO
YES
DERIVE LIGHT INTENSITY VARIATION TIME FUNCTION
22
DERIVE DISPLAY BRIGHTNESS OPTIMAL VALUE
24
FUNCTION & BRIGHTNESS TABLE (ROM)
28
DISPLAY BRIGHTNESS CONTROL
25

FIG.5



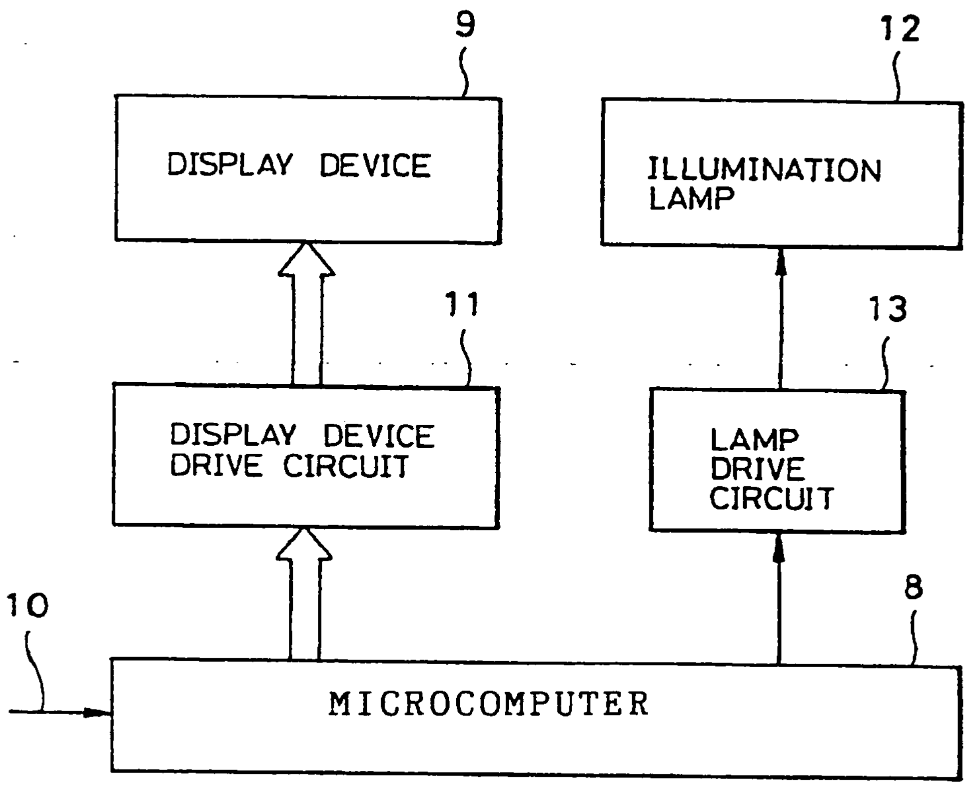
10^4
10^3
10^2
10^1
A
A'
B
B'
10^3
10^2
10^1
1
10^{-1}
ENVIRONMENTAL LIGHT INTENSITY (rℓx)
0
5
10
15
20
25
30
DISPLAY BRIGHTNESS (cd/m^2)
t (minute)

FIG.6



C
C'
D'
D
10^4
10^3
10^2
10^1
10^3
10^2
10^1
1
10^{-1}
ENVIRONMENTAL LIGHT INTENSITY (rℓx)
0
1
2
3
4
5
t (minute)
DISPLAY BRIGHTNESS (cd/m^2)

FIG.7
(PRIOR ART)



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DISPLAY DEVICE

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to a display device. More specifically, the invention relates to a display control device controlling brightness of display of various display equipments installed in a vehicular cabin.

Description of the Related Art

Fig. 7 is a block diagram of a mobile phone installed within a vehicular cabin as disclosed in Japanese Unexamined Patent Publication (Kokai) No. 56-71343. In Fig, a brightness control line 10 is connected to a vehicular battery (not shown) via a lighting switch (not shown). When the lighting switch is turned ON, a battery voltage is applied to the brightness control line 10.

A microcomputer 8 is responsive to the battery voltage applied to the brightness control line 10 to control display of a display arrangement 9 via a display device drive circuit, and, in conjunction therewith, to perform lighting control for an illumination lamp 12 via a lamp driver circuit 13.

While the lighting switch is held OFF, the battery voltage is not applied to the brightness

control line 10 and therefore, the display brightness of the display arrangement 9 is not controlled. Also, lighting control for the illumination lamp 12 is not performed.

In such conventional display equipments to be installed in the vehicular cabin, there is provided a manually operable dimmer circuit for controlling lighting intensity of the display arrangement, illumination lamp and further a back-light for display in association with the vehicular lighting switch or an automatic dimmer circuit for automatically controlling lighting intensity of the display arrangement or the back-light with taking a predetermined light intensity level as a threshold value.

In such conventional display control system, it has been difficult to assure good visibility in a wide brightness range from direct insolation of the sun beam to the dark. Also, the brightness control of the display equipment cannot satisfactorily follow to adaption of human pupil for abrupt variation of the light intensity at entrance and exit of tunnel.

SUMMARY OF THE INVENTION

Therefore, it is an object of the present invention to provide a display device which can detect variation in time and can automatically control light intensity of the display arrangement

and back-light so as to adapt variation of the light intensity to adaption of opening degree of human pupil.

Another object of the present invention is to provide a display device which can assure good visibility in a wide range of light intensity from direct insolation of sun beam to the dark.

According to one aspect of the invention, a display device comprises:

display means for displaying character and/or graphic pattern;

light detecting means for detecting environmental light intensity of the display means and generating a detection signal depending upon the detected light intensity;

light intensity variation time function calculating means responsive to the detection signal for calculating a time function of variation of the light intensity;

display brightness determining means for determining a display brightness of the display means preliminarily set by predicting a time function of variation of a human pupil open degree corresponding to the derived light intensity variation time function; and

display control means for performing brightness control of the display means according to

the determined display brightness.

In the preferred construction, the display brightness determining means is a storage table storing display brightness information preliminarily determined by predicting the time function of variation of the human pupil open degree corresponding to the light intensity variation time function.

The display device may further comprises an analog-to-digital converting means for converting the detection signal into a digital signal, then, the light intensity variation time function calculating means may have a time dependent variation information generating means for deriving a time dependent variation information indicative of variation of the digital signal in time responsive to variation of the detection signal, and the display brightness determining means may include a reference means for making reference to the storage table depending upon the time dependent variation information derived by the time dependent variation information generating means to take the result of making reference to the stage table as the display brightness information. Preferably, the storage table is a read-only memory taking the time dependent variation information as an address input and storing the display brightness information corresponding to respective addresses.

In such case, it is preferred that the time dependent variation information is expressed by a given m bits of digital signal, the reference means takes an upper n bits, in which n is greater than zero and smaller than m, as the address input of the read-only memory, and the read-only memory stores 2^n of display brightness information respectively determined corresponding to address inputs with respect to 2^n of combination patterns of the upper n bits.

The display brightness determining means may also include a pupil open degree variation time function table set by preliminarily predicting time function of variation of human pupil open degree variation corresponding to the light intensity variation time function and a display brightness table preliminarily storing display brightness information indicative of optimal display brightness of the display means corresponding to the pupil open degree variation time function.

Similarly, the pupil open degree variation time function table may be a read-only memory taking the light intensity variation time function as address input and storing pupil open angle variation time functions respectively corresponding to the address inputs, and the display brightness table may also be a read-only memory taking the pupil open degree variation time function as an address input

and storing the display brightness information corresponding to respective address inputs.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be understood more fully from the detailed description given herebelow and from the accompanying drawings of the preferred embodiment of the invention, which, however, should not be taken to be limitative to the present invention, but are for explanation and understanding only.

In the drawings:

Fig. 1 is a schematic functional block diagram of the preferred embodiment of a display device according to the present invention;

Fig. 2 is a flowchart showing operation of a CPU 3 in the block of Fig. 1;

Fig. 3 is a chart showing variation of open degree of a human pupil in time in response to variation of environmental light intensity in time, and an example of control of a brightness of display in time in relation to variation of the open degree of the pupil in time; and

Fig. 4 is a flowchart showing another operation of the CPU 3 in the block of Fig. 1;

Figs. 5 and 6 are illustration showing examples of variation of the environmental light intensity and examples of control of brightness for

display corresponding thereto; and

Fig. 7 is a block diagram showing an example of a conventional display control of a display equipment in a vehicular cabin.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be discussed hereinafter in detail in terms of the preferred embodiments with reference to the drawings, particularly to Figs. 1 to 6. In the following description, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be obvious, however, to those skilled in the art that the present invention may be practiced without these specific details. In other instance, well-known structures are not shown in detail in order to unnecessary obscure the present invention.

Fig. 1 is a schematic block diagram showing one embodiment of a display device according to the present invention. A display device 1 is adapted to display characters, graphic patterns and so forth. As the display arrangement 1, a fluoroluminescent display devise may be employed. A display device drive circuit 2 controls a brightness of display in the display device 1.

In order to detect an environmental light intensity, a photo sensor 4 is provided. The

photosensor 4 may comprise a phototransistor. The photosensor 4 is arranged in the vicinity of the display device 1 but will not be influenced by the light discharged from th display device 1. The photosensor 4 generates a light detection signal indicative of the environmental light intensity. The light detection signal of the photosensor 4 is amplified by an amplifier 5 to be elevated at a level where an analog-to-digital (A/D) converter 6 is operable.

A light detection information in a form of a digital signal as converted by the A/D converter 5 is supplied to a CPU 3. The CPU 3 processes the light detection information through a process illustrated in Fig. 2. By this process, a brightness of display of the display device 1 is optimally controlled depending upon the environmental light intensity.

Referring to Fig. 2, the photosensor 4 constantly detects the environmental light intensity to constantly supply the light detection signal to the CPU 3 via the amplifier 5 and the A/D converter 6 (step 20). Now, it is assumed that a vehicle enters into a tunnel, the light intensity is varied so that the light detection signal of the photosensor 4 is varied accordingly. Variation of the light intensity is output as variation of the light

detection signal of the photosensor. The digital signal of the A/D converter 6 is varied accordingly.

When variation of the light intensity is detected (step 21), an absolute level of the environmental light intensity and a time function of the variation thereof are derived in response thereto (step 22). The time function of variation of the environmental light intensity may be calculated from the absolute level of the light intensity and a differentiated value thereof representative of variation thereof in time.

Corresponding to the time function of the light intensity variation, a time function of an open degree of human pupil can be determined in straightforward manner. Therefore the light intensity variation time function and the pupil open degree time function are stored in a function table 26 with correspondence in one to one manner. Then, on the basis of the light intensity variation time function derived at the step 22, the function table is made reference to read out the univocal corresponding pupil open degree time function to determine the pupil open degree time function (step 23).

Since the optimal brightness of the display device 1 is univocal determined corresponding to the pupil open degree time function, the pupil open

degree time function and the optimal brightness are preliminarily set in a display brightness table 27 in one to one basis. Then, the display brightness table 27 is made reference to on the basis of the pupil open degree time function determined at the step 23, the optimal brightness univocal determined corresponding to the pupil open degree time function (step 24).

According to the optimal brightness thus determined, the CPU 3 controls brightness of the display device 1 via the display device drive circuit 2 (step 25).

Fig. 3 shows one example of variation of the light intensity in time and corresponding variation of the pupil open degree in time, and further shows optimizing control of the display brightness corresponding to variation of the pupil open degree in time.

Assuming that the vehicle enters into a tunnel from a bright area into a tunnel at a timing t_1, the environmental light intensity is abruptly varied from bright to dark. Within a few seconds from the timing t_1 to a timing t_2, the human pupil falls into dark change dazzlement state to abruptly open the pupil up to a certain open degree. Accordingly, during this period T_1, the display brightness of the display device 1 is abruptly

reduced corresponding to abrupt opening of the pupil.

A period T_2 following the timing t_2 is a period, in which the human pupil moderately increase the open degree for adapting the human vision to the dark environment. During this period T_2, the display brightness is gradually reduced according to moderate increasing of the open degree of the human pupil.

At a timing t_3, the vehicle exits from the tunnel, the environmental light intensity is abruptly increased to be bright from dark. With a few seconds period T_3 between the timing t_3 to a timing t_4, the human pupil is in bright change dazzlement state. During this period, the human pupil abruptly decreases the open degree up to a certain open degree. Therefore, during this period T_3, the display brightness is abruptly increased according to closing state of the pupil.

In the human vision, it has been known that dark adaptation upon variation from bright environment to dark environment will take several minutes to several tens minutes. Therefore, the brightness is optimally controlled moderately as shown in the period T_2 according to progress of dark adaptation. On the other hand, it is also known that light adaptation upon variation from dark environment to bright environment will take approximately one minutes. Therefore, the brightness control

corresponding to light adaptation is optimally performed more quickly than that corresponding to dark adaptation as shown in the period T_3.

Three variation characteristics (function) in time as illustrated in Fig. 3 are determined in univocal manner. Therefore, these characteristics are preliminarily stored in the function tables 26 and 27. In the function table 26, the time function of variation of pupil open degree with respect to the time function of variation of the light intensity is stored. On the other hand, in the display brightness table 27, the time function of variation of the optimal display brightness with respect to the time function of the variation of the open degree of the pupil is stored.

These tables 26 and 27 may be stored in a read-only memory (ROM). For an address input of the table 26, the time function of variation of the light intensity is supplied. On the other hand, for the address input of the table 27, the time function of variation of the pupil open degree is supplied.

Manner of variation of the light intensity can be considered in wide variation other than that illustrated at that uppermost position in Fig. 3. In practice, it is not possible to completely adapt the brightness control for all of patterns of light intensity variation. Therefore, typical four to

eight light intensity variation patterns, for example, are preliminarily determined. Then, with respect to these four to eight light intensity variation patterns, the time functions of pupil open degree variation is actually measured to store in the table 26. Also, with respect to the four to eight time functions of pupil open degree variation, the optimal values of display brightness of the display device is actually measured and stored in the table 27.

When the light intensity variation patterns are set at typical four to eight patterns as set forth above, manner of discriminating the light intensity variation pattern with respect to the set four to eight patterns is as follows.

Namely, for deriving the time function of the light intensity variation (step 22), it is derived on the basis of the absolute level of the light intensity and the variation amount in time (differentiated value). When the time function of the light intensity variation is expressed by m bits, combination of upper n ($0 < n < m$) bits in the m bits is used to formulate 2^n (when n = 2 to 3, 4 to 8 patterns) bit patterns to be used as address input for the function table 26.

While the optimal display brightness is determined utilizing the function table 26 and the

display brightness table 27 in the example of Fig. 2, it may be possible to aggregate both tables into a single table. Fig. 4 shows an embodiment employing a single table 28.

In the embodiment of Fig. 4, the step 23 in Fig.2 for determining the time function of the pupil open degree variation is neglected, and instead, the display brightness information in relation to the time function of the light intensity variation is preliminarily stored in the table 28. In this case, the display brightness stored in the table 28 is the optimal value set by preliminarily predicting the time function of variation of the pupil open degree corresponding to the time function of the light intensity variation.

Even in this example, the table 28 may be set in the read-only memory. Also, the light intensity variation patterns are classified into typical four to eight patterns, and the optimal display brightness information respectively corresponding to the set four to eight light intensity variation patterns are stored in the ROM through actual measurement, similarly to the embodiment of Fig. 2.

It should be noted that, Figs. 5 and 6 shows actual examples of display brightness control A', B', C', D' with respect to environmental light

intensity variation A, B, C, D. Fig. 5 shows the examples of dark adaptation control in the case where the environmental light intensity is varied from bright to dark abruptly with respect to the examples A and B. In practice, with respect to each of the examples A and B of the environmental light intensity variation, the display brightness is controlled in according to an elapsed time in stepwise fashion as illustrated by A' and B' approximating the human dark adaptation characteristics.

Fig. 6 shows the examples of light adaptation control in the case where the environmental light intensity is varied from dark to bright abruptly, with respect to the examples of C and D. In practice, with respect to each of the examples C and D of the environmental light intensity variation, the display brightness is controlled in according to an elapsed time in stepwise fashion as illustrated by C' and D' approximating the human light adaptation characteristics.

As set forth above, according to the present invention, even when the light intensity in the vehicular cabin is varied, good visibility is certainly obtained so as not to cause trouble in driving of the vehicle. Therefore, upon entering into the tunnel in driving under daylight or at the transition from brightly lighted zone to the dark

zone in the night, the display brightness can be smoothly varied according to adjusting period of the human pupil. Therefore, it becomes possible to avoid temporary dazzlement or dazing due to excessive display brightness.

Although the invention has been illustrated and described with respect to exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions and additions may be made therein and thereto, without departing from the spirit and scope of the present invention. Therefore, the present invention should not be understood as limited to the specific embodiment set out above but to include all possible embodiments which can be embodies within a scope encompassed and equivalents thereof with respect to the feature set out in the appended claims.

Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

The appended abstract as filed herewith is included in the specification by reference.

WHAT IS CLAIMED IS:

1. A display device comprising:

display means for displaying character and/or graphic pattern;

light detecting means for detecting environmental light intensity of said display means and generating a detection signal depending upon the detected light intensity;

light intensity variation time function calculating means responsive to said detection signal for calculating a time function of variation of the light intensity;

display brightness determining means for determining a display brightness of said display means preliminarily set by predicting a time function of variation of a human pupil open degree corresponding to the derived light intensity variation time function; and

display control means for performing brightness control of said display means according to the determined display brightness.

2. A display device as set forth in claim 1, wherein said display brightness determining means is a storage table storing display brightness information preliminarily determined by predicting the time function of variation of the human pupil

open degree corresponding to the light intensity variation time function.

3. A display device as set forth in claim 2, which further comprises an analog-to-digital converting means for converting said detection signal into a digital signal;

said light intensity variation time function calculating means has a time dependent variation information generating means for deriving a time dependent variation information indicative of variation of said digital signal in time responsive to variation of said detection signal; and

said display brightness determining means includes a reference means for making reference to said storage table depending upon the time dependent variation information derived by said time dependent variation information generating means to take the result of making reference to the storage table as said display brightness information.

4. A display device as set forth in claim 3, wherein said storage table is a read-only memory taking the time dependent variation information as an address input and storing said display brightness information corresponding to respective addresses.

5. A display device as set forth in claim 4, wherein said time dependent variation information is expressed by a given m bits of digital signal,

said reference means takes an upper n bits, in which n is greater than zero and smaller than m, as the address input of the read-only memory, and

said read-only memory stores 2^n of display brightness information respectively determined corresponding to address inputs with respect to 2^n of combination patterns of the upper n bits.

6. A display device as set forth in claim 1, wherein said display brightness determining means includes a pupil open degree variation time function table set by preliminarily predicting time function of variation of human pupil open degree variation corresponding to said light intensity variation time function and a display brightness table preliminarily storing display brightness information indicative of optimal display brightness of said display means corresponding to said pupil open degree variation time function.

7. A display device as set forth in claim 6, wherein said pupil open degree variation time function table is a read-only memory taking said light intensity variation time function as address

input and storing pupil open angle variation time functions respectively corresponding to the address inputs.

8. A display device as set forth in claim 7, wherein said display brightness table is a read-only memory taking the pupil open degree variation time function as an address input and storing said display brightness information corresponding to respective address inputs.

9. A display device substantially as herein described with reference to Figures 1 to 6 of the accompanying drawings.

The Patent Office 21

Application No:	GB 9426307.6	**Examiner:**	Mr. G.M.Pitchman
Claims searched:	1 to 9	**Date of search:**	10 March 1995

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.N): G5C(CHB,CHX) G1A(AMS, PF4R)

Int Cl (Ed.6): G09G3/34

Other: ONLINE:EDOC WPI JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	EP 0145966A2	(General Electric)-see page 6 line 27 to page 7 line 6	1
X	EP 0115575A2	(Bosch)-see abstract	1
X	US 5347293	(Wiedermann)-see column 3 line48 to column 4 line 15	1
X	US 4760389	(Aoki)-see column 3 line 25 to column 4 line 4	1

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
&	Member of the same patent family		